Characterization of $U_yNd_{1-y}O_{2+x}$ and $U_yCe_{1-y}O_{2+x}$ spheres produced by internal gelation

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In the advanced nuclear fuel cycle, partitioning and transmutation (P&T) is the key strategy to reduce spent nuclear fuels radiotoxicity and volume. During this process long-lived minor actinides (MA) are separated from spent fuel (partitioning) and burned up (transmutation) in fast reactor systems to short-lived radioisotopes.

An essential link between the partitioning and the transmutation is the conversion of the separated minor actinides into fresh fuel suitable for homogeneous (MA contents lower than 5 %) or heterogeneous minor actinide recycling (MA contents ranging between 10 % and 30 %).

Current research focuses on the complete reprocessing cycle from spent nuclear fuel to fresh transmutation fuel. Regarding the constitution of the transmutation fuel, particle fuel (sphere-pac fuel strategy) offers beneficial properties compared to traditional pellet fuel. Particles can be prepared without any formation of dust via wet chemical routes and they can directly be inserted into a fuel pin without any mechanical treatment. Strategies to fulfill this task are sol-gel processes, where a stable solution containing the desired metals, the sol, is converted into a solid gel.

In this study we produced simulated transmutation fuel: Spherical UO_2-based particles, by means of the sol-gel route via internal gelation. Pure UO_2 particles and particle compositions of $U_yNd_{1-y}O_{2+x}$ and $U_yCe_{1-y}O_{2+x}$ were prepared with lanthanide contents ranging from 5 % to 40 %.

The trivalent lanthanides act as simulants for the minor actinides. Nd(III) was used to simulate Am(III). Cerium was used in both the trivalent and the tetravalent state, simulating the internal gelation process of plutonium to fabricate MOX-based transmutation fuel. Feed solutions containing Ce(III) or Ce(IV) were used to investigate the influence of the oxidation state of the metal on the gelation process and the quality of the final particles. The feed solution was characterized by UV/VIS spectroscopy.

The sintering behavior of the gelled particles was studied by thermogravimetric analysis (TGA). Scanning electron microscopy (SEM) investigations were applied to determine the geometrical shape and the homogeneity of the particles. The crystal structure was analyzed via powder X-ray diffraction (XRD).